

Title of the Invention:

Flip-Chip BGA Semiconductor Device for Achieving a Superior Cleaning Effect

Background of the Invention:

1. Field of the Invention:

5           The present invention relates to a semiconductor device, and more particularly to a flip-chip BGA (Ball Grid Array) semiconductor device.

2. Description of the Related Art:

          In the process of assembling a flip-chip BGA, the substrate is normally cleaned after soldering IC chips to the substrate by means of balls. If this  
10       cleaning is inadequate, substances such as flux that is used in soldering will not be completely removed from the substrate, and these substances will remain as a residue on the substrate surface or chip surface. This residue is one factor that can cause a decrease in the assembly yield.

          Japanese Patent Laid-Open Publication No. H10-041350 discloses one  
15       substrate cleaning method of the prior art. In this method, enclosure walls 121 are provided around a cleaning area that includes the mounting area of semiconductor chip 114 on substrate 111, as shown in FIG. 1 and FIG. 2. Cleaning fluid 131 flows into the space that is enclosed by enclosure walls 121. Aperture 116 is formed in the bottom surface of substrate 111, and cleaning fluid  
20       131 that has flowed in is discharged from aperture 116. At this time, cleaning fluid 131 that flows toward aperture 116 flows through gaps between contact pads 115 that are arranged between semiconductor chip 114 and substrate 111, and this flow of cleaning fluid 131 produces the cleaning effect.

          It has now been discovered that this cleaning method has the following  
25       problems:

(1)       To obtain an increased cleaning effect, a rapid flow of cleaning fluid 131

between semiconductor chip 114 and substrate 111 is advantageous, but cleaning routes 141 are not straight, and a rapid flow of cleaning fluid 131 is therefore difficult to achieve.

(2) A cleaning process cannot be performed for vertically stacked  
5 substrates 111, and the production efficiency is therefore impaired.

(3) The necessity of forming aperture 116 in the middle of substrate 111 reduces the area that can be used for routing lines on substrate 111 and thus restricts the freedom of line routing.

In the prior art, an adequate cleaning effect could not be obtained due to  
10 the above-described points (1) and (2), and residue therefore tended to remain on substrate 111. Residue that remains may prevent underfill resin, which is subsequently injected between substrate 111 and semiconductor chip 114, from achieving adequate bonding with substrate 111 or semiconductor chip 114, and therefore may cause defects in the close adhesion of the underfill resin.

#### 15 Summary of the Invention:

It is an object of the present invention to provide a flip-chip BGA semiconductor device of a construction that enables adequate cleaning following soldering of a chip to the substrate by means of balls in order to improve the assembly yield of a flip-chip BGA semiconductor device.

20 The flip-chip BGA semiconductor device of the present invention is constructed with a semiconductor chip mounted on the substrate by a reflow process. A stiffener is bonded by means of an adhesive to the area surrounding the semiconductor chip on the surface of the substrate on which the semiconductor chip is mounted. Gaps are provided between this stiffener and  
25 the substrate that each extend outwardly from positions that confront opposite sides of the semiconductor chip and that communicate with the ends of the

flip-chip BGA semiconductor device.

In this flip-chip BGA semiconductor device, when cleaning fluid is caused to flow from the side of one gap to the side of the other gap, the cleaning fluid passes through one gap, flows between the semiconductor chip and substrate, and is discharged from the other gap, during which time the flow is virtually unhindered and the force of the cleaning fluid therefore maintained. As a result, cleaning fluid can easily be caused to flow at high speed between the semiconductor chip and substrate, and an increased cleaning effect can therefore be obtained.

In addition, this cleaning method maintains this effect even when cleaning a plurality of stacked flip-chip BGA semiconductor devices, and the method therefore both allows effective cleaning of a multiplicity of flip-chip BGA semiconductor devices and achieves greater production efficiency.

In the present invention, at least one of the gaps on two sides of a semiconductor chip is preferably provided across the width of a side of the semiconductor chip that the gap confronts. This construction allows cleaning fluid to flow effectively over the entire extent of the bonding portion of the semiconductor chip and the substrate, and can therefore obtain an excellent cleaning effect throughout the entire area.

The gaps between the substrate and the stiffener may be formed by providing depressions in the substrate, or may be formed by providing depressions in the stiffener. In the latter case, it is also possible not to provide adhesive in portions in which the depressions are formed, whereby the gaps can be made larger and the cleaning fluid can be caused to flow more easily. In any case, wiring can be provided even in areas of the substrate in which the gaps are provided, and the degree of freedom in routing wiring is therefore not

restricted.

The above and other objects, features, and advantages of the present invention will become apparent from the following description with reference to the accompanying drawings, which illustrate examples of the present invention.

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#### Brief Description of the Drawings:

FIG. 1 is an exploded perspective view of a flip-chip BGA semiconductor device of the prior art;

FIG. 2 is a cross-sectional view showing the state of the flip-chip BGA semiconductor device of FIG. 1 during cleaning;

FIG. 3a is a plan view of the flip-chip BGA semiconductor device of the first embodiment of the present invention;

FIG. 3b is a cross-sectional view taken along line A-A' of FIG. 3a;

FIG. 3c is a cross-sectional view taken along line B-B' of FIG. 3a;

FIG. 4 is a cross-sectional view showing the state of the flip-chip BGA semiconductor device that is shown in FIG. 3a during cleaning;

FIG. 5 is a flow chart of the assembly steps that precede and follow the cleaning step of the flip-chip BGA semiconductor device that is shown in FIG. 3a;

FIG. 6 is a sectional view of the flip-chip BGA semiconductor device for which the assembly steps of FIG. 5 have been completed;

FIG. 7a is a plan view of the flip-chip BGA semiconductor device according to the second embodiment of the present invention;

FIG. 7b is a sectional view taken along line A-A' of FIG. 7a;

FIG. 7c is a sectional view taken along line B-B' of FIG. 7a;

FIG. 8a is a plan view of the flip-chip BGA semiconductor device

according to a modification of the second embodiment of the present invention;

FIG. 8b is a sectional view taken along line A-A' of FIG. 8a; and

FIG. 8c is a sectional view taken along line B-B' of FIG. 8a.

5                      Detailed Description of the Preferred Embodiments:

We first refer to FIGs. 3a to 3c, FIG. 4 and FIG. 6 in accompaniment with the flow chart of FIG. 5 to explain the assembly steps of the flip-chip BGA of the first embodiment of the present invention.

10                      To fabricate flip-chip BGA 10, substrate 11 to which stiffener 12 is attached by adhesive 13 is first prepared, as shown in FIGs. 3a to 3c. An epoxy resin or a mixture of an epoxy resin and olefin resin can be used as adhesive 13.

15                      An opening is formed in stiffener 12 in the vicinity of the center of substrate 11, and electrodes 18 for connecting the semiconductor chip are arranged in the portion of the surface of substrate 11 that is exposed by this opening, as shown in FIG. 6. In addition, electrodes 19 for connecting to the outside are arranged on the surface of the side of substrate 11 that is opposite the surface on which stiffener 12 is attached; and electrodes 18 for connecting to a semiconductor chip and electrodes 19 for connecting to the outside are  
20                      connected by way of wired circuits (not shown in the figure) that are provided on substrate 11.

25                      Depressions 16 are provided on the surface of substrate 11 on which stiffener 12 is attached, whereby gaps 17 are formed between substrate 11 and adhesive 13 that is bonded to stiffener 12. As gaps 17, passages that pass from one side of flip-chip BGA 10 and through the opened portion of stiffener 12 are provided on the two opposing sides with this opening interposed.

Semiconductor chip 14 is next arranged in the opening of stiffener 12 and then bonded by a reflow process (soldering) to semiconductor chip connection electrodes 18 by means of balls 15, whereby semiconductor chip 14 is mounted.

5           In the cleaning step that follows, a plurality of similar flip-chip BGAs 10 are stacked and loaded in cassette 20 as shown in FIG. 4 and then conveyed into cleaning tank 30. Circulation piping provided with pump 33 is connected to cleaning tank 30 with inflow port 32 into cleaning tank 30 and outflow port 35 from cleaning tank 30 being provided at opposite positions of cleaning tank 30.

10          Cassette 20 is arranged such that, of gaps 17 that are formed by depressions 16 in substrate 11 for each flip-chip BGA 10, gap 17 that is located on one side of semiconductor chip 14 confronts the inflow port 32 side and gap 17 located on the other side confronts the outflow port 35 side.

            With the activation of pump 33, cleaning fluid /cleaning water 31 that is  
15          under pressure from pump 33 becomes jet current 34 and flows through cleaning tank 30. This jet current 34 enters each flip-chip BGA 10 through gaps 17 on the inflow port 32 side that are formed by depression 16 in substrate 11, passes through the spaces between balls 15 that are arranged between semiconductor chips 14 and substrates 11, and is discharged from the gaps on  
20          the outflow port 35 side.

            The cleaning of flip-chip BGA 10 is thus carried out by, for example, the flow of glycol cleaning fluid/cleaning water 31 at a fluid temperature of 50 to 70 °C and a flow rate of approximately 600 liters/minute over a period of 1800 seconds.

25          In this way, substances such as flux that adhered to substrate 11 during the reflow process to bond (solder) semiconductor chip 14 to substrate 11 are

effectively removed, and the surfaces of substrate 11 and semiconductor chip 14 are cleaned without any residue being left behind.

Underfill resin 20 is then injected between semiconductor chip 14 and substrate 11, and heat sink 21 is applied to the side of substrate 11 that is  
5 opposite the side on which semiconductor chip 14 is mounted. Underfill resin 20 adheres well to the surfaces of substrate 11 and semiconductor chip 14 because both surfaces have been effectively cleaned.

We next refer to FIGs. 7a to 7c to describe the flip-chip BGA according to the second embodiment of the present invention.

10 In contrast to flip-chip BGA 10 of the first embodiment in which depressions 16 were provided in substrate 11 to form gaps 17, in the present embodiment, depressions 46 are provided in stiffener 42 to form gaps 47.

As in the first embodiment, as gaps 47, passages that communicate with the opening of stiffener 42 for mounting semiconductor chip 44 are  
15 provided on two opposing sides with the opening interposed.

Flip-chip BGAs 40 of this embodiment can also be cleaned in cleaning tank 30 that is shown in FIG. 2. In this case, flip-chip BGAs 40 of this embodiment are configured such that jet current 34 that passes through gap 47 between stiffener 42 and substrate 41 (adhesive 43) advances directly to strike  
20 against semiconductor chip 44, whereby jet current 34 can be directed substantially directly toward the spaces between balls 45, whereby an excellent cleaning effect can be obtained.

Moreover, as a modification of flip-chip BGA 40 of the second embodiment, a construction may be adopted in which depressions 46 are  
25 provided in portions of stiffener 42, and further, adhesive 53 is not provided in these portions, as shown in FIGs. 8a to 8c. This construction enables an

enlargement of gaps 57 that are formed between substrate 41 and the depression 46 portions of stiffener 42, and accordingly, can raise the cleaning effect of jet current 34.

As described in the foregoing explanation, in the cleaning step, cleaning  
5 fluid/cleaning water 31 becomes jet current 34 that passes through gaps 17, 47  
or 57 between substrates 11 and 41 and stiffeners 12 and 42, and then passes  
between semiconductor chips 14 and 44 and substrates 11 and 41 while  
substantially maintaining the force of this current, whereby a superior cleaning  
effect can be obtained, and whereby the space between thin semiconductor  
10 chips 14 and 44 and substrates 11 and 41 can be easily and effectively cleaned  
in a short time period without leaving any soldering flux residue. In addition, the  
use of this cleaning method enables effective cleaning without any loss of  
cleaning effect even when the cleaning method is employed for a case in which  
a plurality of flip-chip BGAs 10 and 40 are stacked and cleaned, and thus can  
15 obtain superior production efficiency when mass-producing flip-chip BGAs 10  
and 40.

While preferred embodiments of the present invention have been  
described using specific terms, such description is for illustrative purposes only,  
and it is to be understood that changes and variations may be made without  
20 departing from the spirit or scope of the following claims.

For example, although a case was described in each of the  
embodiments in which, as gaps 17, 47, and 57, passages of the same shape  
were formed on the inflow side and outflow side of jet current 34 at symmetric  
positions with respect to semiconductor chips 14 and 44, the construction need  
25 not conform to this configuration. For example, a construction may be adopted  
in which the width of gaps 17, 47, and 57 on the outflow side of jet current 34 are



narrower or wider than on the inflow side, or in which a plurality of gaps 17, 47, and 57 extending in a striped pattern in the direction of flow are provided. In any case, gaps 17, 47, and 57 on at least one side of the two opposite sides that sandwich semiconductor chip 14 are preferably provided across the width of the side of semiconductor chip 14 that these gaps 17, 47, and 57 confront so that jet current 34 flows over the entire area of the connecting portions between semiconductor chip 14 and substrate 11, whereby a superior cleaning effect can be obtained over the entire connecting portion.